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Physicochemical Analysis of non-rhizosphere and rhizosphere soil of *Sorghum bicolor* (Guinea corn) field

[1]*Abdullahi M., [2]Oyeyiola G.P, [2]Sule I.O., [1]Adamu M.S and [3]Olarongbe G.O

[1]Department of Biological Sciences,
Niger State Polytechnic,
Zungeru.

[2]Department of Microbiology,
University of Ilorin
Nigeria.

[3]Department of Science Laboratory Technology,
IAS,
Kwara State Polytechnic,
Ilorin.

Email: lddabdul862@gmail.com

Abstract

Soil is one of nature's most dynamic sites of biological interaction, where crop nutrition are found. The rhizosphere is the area surrounding plant roots where microorganisms, particularly bacteria, are active, whereas non-rhizosphere soil, also known as bulk soil, is soil that lacks plant roots and does not belong to any rhizosphere soil. Physicochemical analysis of non-rhizosphere and rhizosphere soil of Sorghum bicolor field was determined. Before planting, physicochemical analysis of a soil was performed, and after planting, rhizosphere and bulk soil of Sorghum bicolor field were determined. Parameters considered in determining the soil's suitability for plant growth and development include, the pH, moisture content, water holding capacity, and organic matter content were all measured. For fourteen weeks, soil samples were collected every two weeks. Rhizosphere soil had pH range of 5.49 ± 0.02 – 8.15 ± 0.02, soil moisture content: 0.56 ± 0.01% – 1.22 ± 0.01, water holding capacity: 43.34 ± 0.47 ml/gm – 53.75 ± 0.55 ml/gm, organic matter: 30.12 ± 0.54 g kg^{-1} – 42.45 ± 0.02 g kg^{-1}. Bulk soil had pH range of 6.72 ± 0.02 – 7.46 ± 0.03, soil moisture: 0.10 ± 0.00% – 2.13 ± 0.02%, water holding capacity: 42.82 ± 0.32 ml/gm – 44.42 ± 0.25 ml/gm and organic matter: 5.68 ± 0.65 g kg^{-1} – 30.13 ± 0.52 g kg^{-1}. Prior to planting Sorghum bicolor, the soil texture revealed that it is sandy loam. After observing the soil, it can be concluded that it is versatile, productive, and capable of supporting the growth of Guinea corn (Sorghum bicolor).

Keywords: Non-rhizosphere, Rhizosphere soil, *Sorghum bicolor*

INTRODUCTION

Soil is one of nature's most dynamic sites of biological interaction, where crop nutrition take place (Oyeyiola *et al*., 2012). The rhizosphere is the area surrounding plant roots, and the substances released from the roots and the metabolic activity of the roots change the

**Author for Correspondence*

characteristics of the soil (Oyeyiola, 2010; Aliyu and Oyeyiola, 2011). Furthermore, microorganism activity, particularly those of bacteria, is increasing in rhizosphere soils (Toal *et al*., 2000).

Minerals, organic matter, water, and air are the four basic components of soil. A typical soil is composed of approximately 45% minerals, 5% organic matter, 20-30% water, and 20-30% air; however, these percentages are at best generalizations; soil is extremely complex and dynamic (Ponge, 2015).

The relative proportions of the various sand, silt, and clay particles that comprise the soil determine the texture. Individual mineral particles form aggregates or peds as a result of their interactions with organic matter, water, and gas via biological and abiotic processes. Where these aggregates can be identified, the soil has developed and can be further classified in terms of color, porosity, consistency, and reaction (acidity) (Ponge, 2015). Water is an important factor in soil development because it aids in the dissolution, precipitation, erosion, transportation, and deposition of the soil's constituent materials. The soil solution is a mixture of water and dissolved or suspended matter that occupies the pore space of the soil (Toal *et al*., 2000).

Sorghum grows primarily on shallow soils with low potential and high clay content, making it unsuitable for corn production. Sorghum grows poorly in sandy soil unless the subsoil has a thick texture. Because sorghum is more tolerant of alkaline salts than other food crops, it can be grown successfully in soils with pH values (KCl) ranging from 5.5 to 8.5. Sorghum can withstand short-term waterlogging better than corn. Soils with a clay content of between 10% and 30% are best suited for sorghum production (Retallack *et al*., 2016).

Microorganisms are abundant in soil, but they only make up 1% of the soil. They are the primary decomposers of the raw materials found in soil. They consume (eat) water, air, and organic matter, and they recycle raw materials into humus. Other microorganisms, such as nitrogen-fixing bacteria, aid in plant nitrogen absorption (Yu *et al*., 2015). Bacteria, actinomycetes, fungi, algae, and protozoa are the different types of soil microorganisms. Each of these groups has characteristics that define it and its role in the soil. Every gram of soil around plants and their roots contains up to 10 billion bacterial cells. The rhizosphere is the name given to this region (Matulich and Martiny, 2015).

Sorghum is grown on a variety of soils in South Africa, with varying rainfall patterns. The drier western region receives about 400 mm of rain per year, while the wetter eastern region receives about 800 mm. Drought-tolerant sorghum is more drought-tolerant than most other food crops, owing to a highly developed and finely branched root system that is extremely effective at absorbing water (Pouyat *et al*., 2002).

MATERIALS AND METHODS

Study Area

The study was conducted in Niger State Polytechnic Zungeru, Wushishi Local government of Niger State. Zungeru is a town in Niger State, Nigeria. Niger State lies on the 3.20° East and longitude 11.30° North. Kaduna State and FCT are her borders to the North-East and South-East respectively; Zamfara State borders the North, Kebbi State in the West, Kogi State in the South and Kwara State in the South West, while the republic of Benin along Agwara LGA boarders her North West (Mohammed, 2002).

Soil Samples Collection

Rhizosphere soil samples (50gram) were carefully collected by uprooting each plant with a sterile trowel and shaking the roots to obtain soil adhering to the roots into sterile polythene bags, while, 50gram of non-rhizosphere soil was collected from the non-rhizosphere region (bulk soil) with a hand trowel into sterile polythene bags labeled and conveyed to microbiology laboratory of Federal University of Technology Minna (Petrenko and Berezhnyal, 2008).

Physicochemical Analyses of the Soil Samples

Determination of soil pH

To determine the pH, twenty grams of sieved air-dried soil were weighed and added to a 250ml beaker. After that, 20 milliliters of distilled water were added. The resulting suspension was left to stand for 30 minutes with intermittent stirring to reach equilibrium. The pH of the suspension was measured using a Pye Unicam pH meter (model 90, MKZ, Cambridge UK) with a glass electrode. The pH meter was calibrated with buffer solutions of pH 4, 7, and 9 before use. (Fawole and Oso, 2001).

Determination of soil moisture content

In an oven at 105 ^{0}C, a crucible was dried to a constant weight (W_1). The soil was then weighed into each Crucible (W_2) and dried for 24 hours at 105 ^{0}C. after which drying, the soil was allowed to cool in a silica gel-containing desiccator before being reweighed. After cooling, it was dried until it reached a constant weight (W_3). The amount of moisture in the soil sample is represented by the difference between the initial weight and the final weight after drying (Xuezhang *et al*., 2016).

$$\frac{W_2 - W_3}{W_2 - W_1}$$

Where: W_1 = weight of crucible only

W_2 = weight of crucible and fresh soil.

W_3 = weight of crucible and soil after drying.

Determination of organic matter content of the soil

In a 250ml conical flask, one gram of air dried and sieved soil was weighed, and 5ml of 1 N $K_2Cr_2O_7$ was added. To disperse the soil in solution, the flask was gently swirled. 10ml of concentrated H_2SO_4 was added to the reagent, which was thoroughly mixed. The mixture was allowed to stand on an asbestos pad for 30 minutes before being allowed to cool. Then 200ml of distilled water was added, followed by 3 to 5 drops of the indicator solution (Pelczar *et al*., 2005)

As a result, 0.4 N $(NH_4)2FeSO_4$ was titrated, and the end point of the solution first appeared greenish, then green, and finally brown.

$$\text{Organic carbon } (\text{g kg}^{-1}) = \frac{(BT - ST) * N * 10}{W}$$

where

BT = Blank Titre value

ST = Sample Titre value

N = Normality of $(NH_4)2FeSO_4$

W = Weight of soil sample

N can be obtained by: $\frac{\text{mL of } K_2Cr_2O_7 \text{ (5 mL)}}{BT}$

Soil organic matter (g kg^{-1}) = OC * 1.72

Determination of Nitrogen.
Ten grams (10g) of air dried and sieved soil were weighed with a weighing balance. The sample was transferred to a 100ml beaker. In the beaker, 0.1g of calcium sulphate was placed. 25ml of deionized water was measured with a graduated cylinder and transferred to the beaker containing the mixtures. These procedures were repeated for each nitrogen soil sample. A stir rod was used to thoroughly mix the contents of each beaker. Samples were placed in a table top shaker and shaken for one minute (Dastgheyb *et al*., 2021).

Determination of Phosphorus and Potassium
Using a weighing scale, 2g of dried and sieved soil was measured and placed in a 100ml beaker. 20ml of Mehlich 2 soil extractant was measured into a 25ml graduated cylinder and transferred to a beaker. The preceding steps were repeated for each phosphorus and potassium. The contents were thoroughly mixed with a stir rod and shaken for five minutes on a shaker table (Dastgheyb *et al*., 2021).

Determination of soil texture
The soil texture was determined using the soil hydrometer method described by Fawole and Oso (2009). Oven dried soil (50 g) was placed in a 1 litre beaker, followed by 200 mL of distilled water and 50 mL of dispersion agent (2Na0H) dissolved in 2 liters of distilled water. After 5 minutes of stirring, the suspension was transferred to a 1 litre measuring cylinder. To make the suspension in the measuring cylinder to the 1 litre mark, distilled water was used. The suspension was vigorously mixed by shaking the cylinder while covering the top with the palm of one hand. The time was recorded after the cylinder was placed on the bench. After allowing the cylinder to stand for 30 seconds, a soil hydrometer was gently inserted into the suspension (Jones *et al*., 2009).

After 10 seconds of insertion, the reading was taken. This provided first hydrometer reading (H_1). The hydrometer was then removed, and a thermometer was inserted into the suspension, yielding the first temperature reading as (T_1). The suspension was allowed to stand for two hours before the second hydrometer reading (H_2) and temperature reading (T_2) were taken (T_2). T_1 and T_2 were converted to Fahrenheit degrees (^{0}F).
The % of sand clay and silt was calculated using the formula below.
% Sand = 100.0 – (H_1+ 0.2 (T_1 – 68) – 2.0)2
% Clay = (H_2 + 0.2 (T_2 – 68) – 2.0) 2
% Silt = 100.0 – (%sand + % clay)
Reference was made to appropriate soil texture triangle after calculating the percentages of sand, clay and silt in the soil to get the soil texture.

Statistical Analysis
The data was statistically analyzed. This included calculating the means, standard deviation, standard error of mean and range. The SPSS (version 21) statistical package was used for this. To distinguish between means, a multiple Duncan range test was used.

RESULTS

Physicochemical properties of the soil sample prior to planting
Table 1 shows the physicochemical properties of the soil sample prior to planting. The pH of the soil is 6.37±0.03. Soil moisture content was low (0.62±0.00%). The sand, silt, and clay compositions of the soil were 72.80±2.61gkg^{-1}, 14.80±1.65gkg^{-1}, and 12.40±1.54gkg^{-1}, respectively. The soil contained 33.82±3.24gkg^{-1} of organic matter and 45.38±2.45% water holding capacity (Table 1).

Table 1: Physicochemical properties of the soil prior to planting

Parameter	Measurement
Soil pH	6.37±0.03
Soil moisture (%)	0.62±0.00
Water holding capacity (%)	45.38±2.45
Organic matter (%)	33.82±3.24
Sand (%)	72.80±2.61
Silt (%)	14.80±1.65
Clay (%)	12.40±1.54
Soil texture	Sandy loam

Data = Mean ±SEM of triplicate determination.

Nutrient analysis of *Sorghum bicolor* soil

Nutrient analysis on non-rhizosphere had more of Phosphorus and Nitrogen content (16.33 and 10.40 Mgkg^{-1} respectively) compare to that of rhizosphere (16.25 and 8.96 Mgkg^{-1} respectively). Similarly, Magnesium content in bulk soil was higher (4.00) compared to (3.52) of rhizosphere. However, rhizosphere had more Potassium and Sodium composition compared to bulk soil.

Table 2 Nutrient analysis of *Sorghum bicolor* soil

Soil	P	N	Mg^+	K^+	Na^+
	Mg kg^{-1}			Cmol kg^{-1-}	
Non-rhizosphere	16.33	10.40	4.00	0.17	0.44
Rizosphere	16.25	8.96	3.52	0.21	0.96

Key:- P: Phosphorus; N: Nitrogen; Mg^+: Magnesium; K^+: Potasium; Na^+: Sodium

Physicochemical properties of the non-rhizosphere soil

Physicochemical properties of the non-rhizosphere soil at interval of two weeks are shown in Table 2. The soils pH ranged from 5.49±0.02 – 8.15±0.02. The water holding capacity ranged from 43.34±0.47 % - 53.75±0.55%, while the moisture content ranged from 0.56 ± 0.01 to 1.22 ± 0.01. The maximum soil pH, moisture and organic matter were observed in the 10th week and the minimum was observed in the 6th week. The organic matter of the soils ranged from 30.13±0.28 to 42.45±0.02 g kg^{-1} (Table 2).

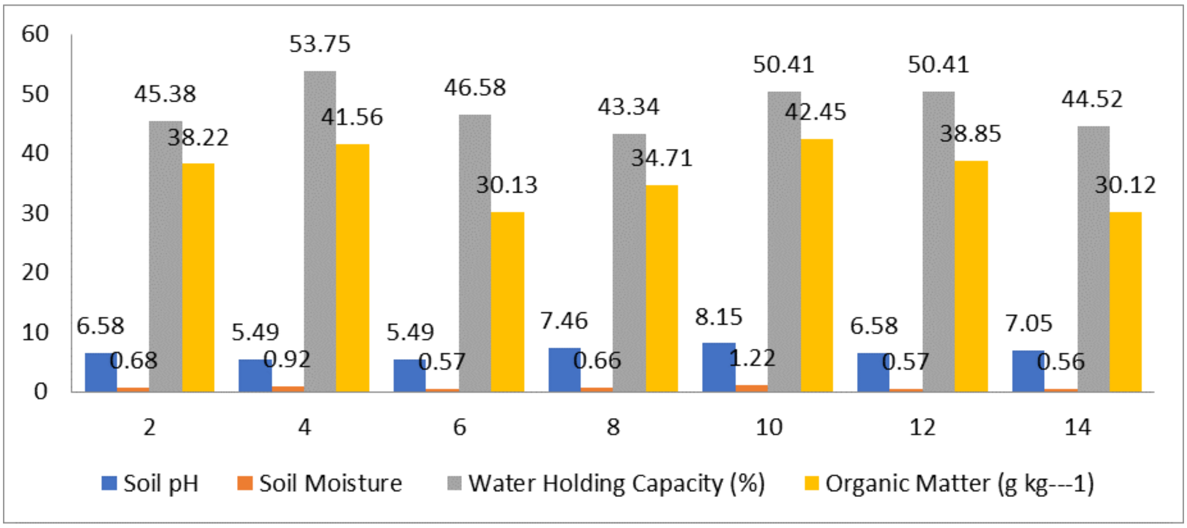

Figure 1: Physicochemical properties of the non-rhizosphere soils of Guinea corn (*Sorghum bicolor*)

Physicochemical properties of the rhizosphere soils

Physicochemical properties of the rhizosphere soil of Guinea corn every two weeks are shown in Table 3. The pH of the rhizosphere soil of guinea corn ranged from 6.72±0.02–7.35±0.01 while the water holding capacity ranged from 42.82±0.32 - 44.32±0.21% and were not significantly different (Table 3). The soil moisture content increases with time, with minimum level at week 2 (0.10±0.00%) and maximum level at week 14 (2.13±0.02%). The level of organic matter fluctuates throughout the study period with the maximum content at 14thweek (30.13±0.52 g kg^{-1}).

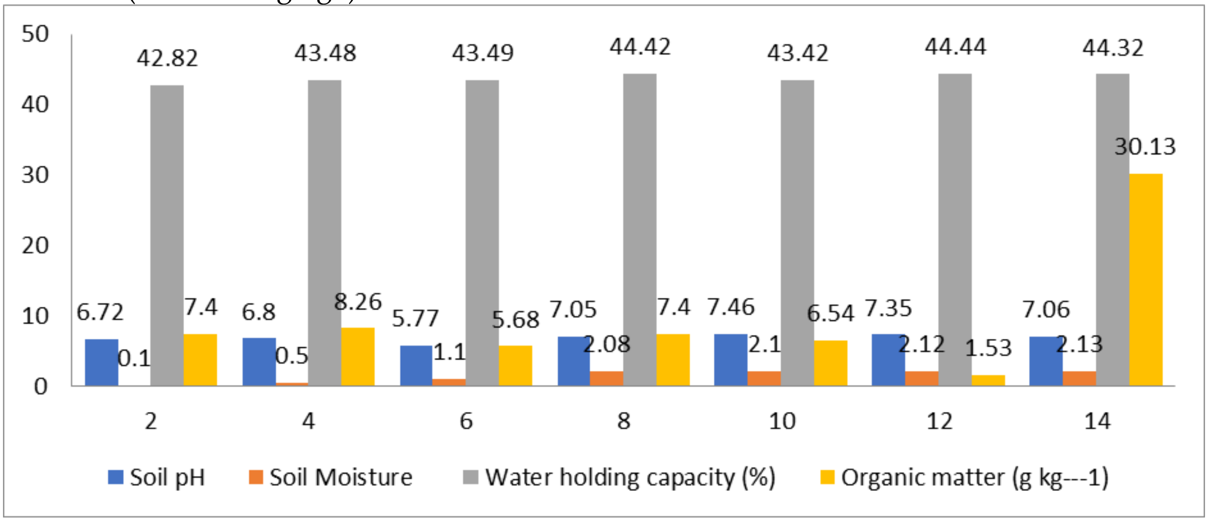

Figure 2: Physicochemical properties of the rhizosphere soil of Guinea corn (*Sorghum bicolor*)

DISCUSSION

Agricultural management has an impact on the physical and chemical composition of the soil, which influences the structure of specific microbial communities (Das and Dkhar, 2011). Soil organic matter (SOM) is a complex mixture of bio-organic components in varying proportions and stages of evolution (Aira *et al*., 2010).

The soil organic content of the soil sample before planting is low in this study (33.823.24gkg^{-1}). The current study also revealed that the soil sample used in this study had sand, silt, and clay compositions of 72.802.61gkg^{-1}, 14.801.65gkg^{-1}, and 12.401.54gkg^{-1}, respectively. The soil's low organic matter content could also be explained by the dominance of sand particles over clay and silt particles. Previous research has also found that aggregate stability and clay content are important factors in determining the amount of SOM in a soil.

Soil aggregates have been shown to physically protect SOM from microbe decomposition (Six *et al*., 1998), whereas a higher clay content allows more organic material to be trapped in ultra-micropores (<1µm) that microbes cannot access (Brady and Weil, 2008). Furthermore, the amount of SOM reported in this study differs from levels reported in other research areas throughout the country (Das and Dakar, 2011).

Low SOM levels are common in tropical soils due to high temperatures and increased decomposing activity of soil microbes (Panwar *et al*., 2010). A lack of SOM contributes to nutrient leaching, decreased soil porosity, and a reduction in soil structural stability (Havlin *et al*., 2005). Interestingly, throughout the 14 weeks of study, the rhizosphere soil of Guinea corn was higher (30.81±0.26 and 42.45±0.78gkg^{-1}) than the levels found in the non-rhizosphere soil, which was accompanied by an increase in moisture content of the rhizosphere soil relative to the non-rhizosphere soil.

This high soil organic matter would improve soil structure and act as high nutrient reservoir for easy accessibility to plants, but they are not rapidly leached out of the soil by rainwater (Brady and Weil, 2008). This high soil organic matter would improve soil structure and act as a high nutrient reservoir for easy access to plants, but rainwater does not rapidly leach it out of the soil (Brady and Weil, 2008).

The pH of rhizosphere soil was higher than that of non-rhizosphere soil. The pH of Guinea corn rhizosphere soil ranged from weekly acidic (6.72±0.02) to weakly alkaline (7.35±0.01). When soil pH is low, the soil becomes acidic, resulting in poor plant growth and development because most plant nutrients become unavailable to plants (Nyoki and Ndakidemi, 2018). As a result, the increased pH of rhizosphere soils observed in this study favours the availability of most plant nutrients, promotes normal plant growth, and eventually increases yield (Condron *et al*., 1993).

CONCLUSION

Having observed the composition of non-rhizosphere and rhizosphere in the soil of the experimental field to be sand, clay, and silt, as well as other parameters such as organic matter content, moisture content, and pH, the soil can be expressed to be versatile, productive, and capable of supporting the growth of Guinea corn (*Sorghum bicolor*).

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REFERENCES

Aira, M., Gómez-Brandón, M., Lazcano, C., Bååth, E., Domínguez, J. (2010). Plant genotype strongly modifies the structure and growth of maize rhizosphere microbial communities. *Soil Biol. Biochem.* 42(12):2276–2281.

Aliyu, M. B. and Oyeyiola G.P (2011). Rhizosphere Bacterial Flora of Groundnut (*Arachisbhypogeae*). *Advances in Environmental Biology*, 5(10): 3196 – 3202. ISSN 1995-0756.

Brady N., and R. Weil. (2008). The nature and properties of soils. 14th ed. *Pearson Prentice Hall, Columbus, OH 4(6): 231 – 242*

Condron, L. M., Tiessen, H., Trasar-Cepeda, C., Moir, J.O., and Stewart, J. W. B. (1993). Effects of liming on organic matter decomposition and phosphorus extractability in an acid humic ranker soil from Northwest Spain. *Biology and fertility of soils*. 15(4): 279–284.

Cowan and Steel's (2001) *Manual for the Identification of medical bacteria.* Cambridge University press. ISBN; 9780511527104

Das B.B. and Dkhar M.S. (2011). Rhizosphere Microbial Population and Physico-chemical Properties as Affected by Organic and Inorganic Farming Practices. *American-Eurasian Journal of Agriculture and Environmental Science*. 10(2): 140- 150.

Dastgheyb, S. S., Shirazi, A. Ahmadi, N. Abdi, H. Toranj Zar, and Khaleghi M. R (2021) Moderate grazing is the best measure to achieve the optimal conservation and soil resource utilization (case study: Bozdaghin rangelands, North Khorasan, Iran), *Environmental Monitoring and Assessment*, 10.1007/s10661-021-09334-1, 193, 9,

Fawole, M. O. and Oso, B. A. (2001). *Laboratory Manual of technology.* Spectrum Books Limited. P127.

Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. (2005). Soil Fertility and Nutrient Management: An Introduction to Nutrient Management. 7th Edition. Pearson/Prentice *Hall. Upper Saddle River, NJ.* .Pp310 – 320

Jones, R.T., Robertson, M.S., Lauber, C.L., Hamady, M.,Knight, R., and Fiere, N. (2009) A comprehensive survey of soil acidobacterial diversity using pyrosequencing and clone library analyses. *ISME J* 3: 442–453.

Matulich K.L, Martiny J.B.H. (2015). Microbial composition alters the response of litter decomposition to environmental change. *Elology*. 96(1): 154–163.

Nyoki, D., and Ndakidemi, P.A. (2018). Selected Chemical Properties of Soybean Rhizosphere Soil as Influenced by Cropping Systems, *Rhizobium* Inoculation, and the Supply of Phosphorus and Potassium after two Consecutive Cropping Seasons. *International Journal of Agronomy*. Volume. ID 3426571, 8 pages

Oyeyiola, G.P, Ajokpaniovo. H, and Aliyu, M.B. (2012). Bacterial flora of the rhizosphere of *Capsicum frutescens World journal of biological research.* 5 (2), 61-66. Website : *www.interscholar.org/wjbr* Published by the Ivorian Society for the Promotion of Sciences (ISPROMS). ISSN: 1994-5108.

Oyeyiola, G.P. (2010). Rhizosphere bacterial flora of *Amaranthus hybridus*. *Research Journal of Microbiology,* 5(2): 137-143.

Oyeyiola G.P.and Agbaje A.B (2013) Physicochemical Analysis of a Soil near Microbiology Laboratory at The University of Ilorin, Main Campus. *Journal of Natural Sciences Research* www.iiste.orgISSN 2224-3186. ISSN 2225-0921: 3(6).

Pelczar, M. J., Chan E.C.S. and Krieg, N. R. (2005). *Microbiology* 5th Edition, Tata Mc Graw Hill Publishing Company Ltd., New Delhi. Pp. 333 – 365.

Petrenko L.R., and Berezhnyal Ye. M, (2008) Soil science practical methods manual. NAU publishing centre. 03041, Kyiv – 41, Geroyev Oborony St., 15. P10 – 12.

Pinton, R., Veranini, Z.and Nannipieri, P. (2007). *The rhizosphere. Biochemistry and organic substances at the soil-plant interface*. New York, USA : *Taylor & Francis Group, LLC. 104 (4). doi*: 10.1093/aob/mcp166

Pouyat, Richard; Groffman, Peter; Yesilonis, Ian; Hernandez, Luis (2002). "Soil carbon pools and fluxes in urban ecosystems"*Environmental Pollution. **116** (Supplement 1): S107–S118. Doi.10.1016/S0269-7491(01)00263-9. PMID. 11833898.*

Ponge, J ean-francois (2015). "The soil as an ecosystem" Biology and Fertility of Soils*. **51** (6): 645–48. Do: 10.1007/s00374-015-1016-1 S2CID 18251180*.

Saberi, A.R and Aishah S.H., (2013): Growth analysis of forage sorghum (*Sorghum bicolor*) varieties under varying salinity and irrigation frequency. *Int. J. Biotechnol*, 2: 130-140.

Toal, M.E., Yeomans, C., Killham, K. and Meharg, A.A. (2000). A review of rhizosphere carbon flow modeling. *Plant Soil* 222: 263-281.

Xuezhang Li, Ming A.N, Shao and Xiaorong Wei (2016) Profile distribution of soil–water content and its temporal stability along a 1340-m long transect on the Loess Plateau, China. *Journal of hydrology (Catena*). Volume 137. Pp77 – 86.

Yu, Charley; Kamboj, Sunita; Wang, Cheng; Cheng, Jing-Jy (2015). "Data collection handbook to support modeling impacts of radioactive material in soil and building structures" *(PDF). Argonne National Laboratory.* Pp. *13–21.*